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REGULAR ARTICLE

Parental reports showed that snoring in infants at three and eight months associated with snoring parents and smoking mothers

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ABSTRACT

Aim: This prospective study examined the prevalence of snoring during infancy and the prenatal and postnatal risk factors for this condition.

Methods: The study population comprised 1388 infants from the CHILD-SLEEP birth cohort, who were recruited in the Pirkanmaa Hospital District, Finland, between 2011 and 2013. Sleep and background factor questionnaires were filled out prenatally by parents and when the infant was three and eight months old.

Results: The prevalence of habitual snoring was 3.2% at the age of three months and 3.0% at eight months, and snoring infants had more sleeping difficulties at those ages, with odds ratios (ORs) of 3.11 and 4.63, respectively. At three months, snoring infants slept for a shorter length of time ($p = 0.001$) and their sleep was more restless ($p = 0.004$). In ordinal logistic regression models, parental snoring (adjusted OR = 1.65 and 2.60) and maternal smoking (adjusted OR = 2.21 and 2.17) were significantly associated with infant snoring at three and eight months, while formula feeding and dummy use (adjusted OR = 1.48 and 1.56) were only associated with infant snoring at three months.

Conclusion: Parental snoring and maternal smoking increased the risk of snoring. Infants who snored also seemed to suffer more from other sleep difficulties.

INTRODUCTION

Sleep-disordered breathing represents a spectrum ranging from primary snoring to obstructive sleep apnoea. Primary snoring refers to snoring with no evidence of apnoea or gas exchange abnormalities (1). Habitual snoring is generally defined as snoring three or more nights per week.

The prevalence of sleep-disordered breathing in children has been quite well studied, but the reported prevalence rates of snoring in infants vary widely (2–6). The prevalence of habitual snoring is estimated to be about 5.0–6.6% of children under one year of age (2,3,6), and in some studies the prevalence even rises to 9–14% (4,5). This may be explained by the heterogeneity of the studies, variation in the definition of habitual snoring and the presence of colds.

The presence of snoring in infants and preschool children has been associated with male gender (7–9), lower socioeconomic status (7,10), African American race (2), chronic rhinitis (9,10), regurgitation (10) and tobacco smoke exposure (11). Snoring has also been associated with restless sleep (2,5,6), parental asthma (7,10) and maternal concern about the child's breathing (2,5). There is evidence that breastfeeding reduces the risk of habitual snoring (4,12,13) and the severity of sleep-disordered breathing (14). Exclusive formula feeding has been significantly associated with habitual snoring (5).

Familial factors also seem to play a role in the development of sleep-disordered breathing. Maternal cigarette smoking is associated with snoring in children (8,10,15). In addition, there seems to be a significant association

Abbreviations
aOR, Adjusted odds ratio; BMI, Body mass index; CI, Confidence interval; OR, Odds ratio; SD, Standard deviation.

Key notes

- This study analysed the prevalence and the risk factors of snoring during infancy. The prevalence of snoring was lower than reported earlier.
- The sleep of snoring infants was shorter and more restless than other infants. Maternal smoking and parental snoring increased the risk of snoring.
- Considering that snoring has been associated with several negative health consequences, it is essential to identify the symptoms of sleep-disordered breathing as early as possible.

between the child's snoring and a history of snoring or the snoring by the mother, father or siblings (9), suggesting that inherited and environmental factors play a role in disordered breathing during sleep.

The main objective of this study was to add to the limited knowledge on infant snoring and the factors associated with it. We examined the prevalence of snoring at the ages of three and eight months, as well as the prenatal and postnatal parental-reported factors that are associated with this condition.

METHODS

Study settings and subjects

This was a prospective study based on the CHILD-SLEEP birth cohort. The study protocol was approved by the Ethics Committee of Pirkanmaa Hospital District on March 9, 2011 (number R11032). The cohort was recruited prenatally in Pirkanmaa Hospital District, Finland. The infants were born between April 2011 and February 2013. A total of 2244 parents were approved to receive the prenatal questionnaires during their visits to maternity clinics, from which 1673 (74%) families returned the baseline questionnaires. The parents filled in the first questionnaire before the mother went into labour. Follow-up measurements took place at three and eight months postnatally. Questionnaires were provided by post to both the mother and father. The infant questionnaire was filled out by the parents together. Details of the recruitment procedure have been reported previously (16). The response rate was 85% at the age of three months and 78% at the age of eight months. The families who did not answer the question concerning snoring were excluded, leaving 1388 infants at the age of three months and 1216 infants at the age of eight months.

Data collection

The sleep questionnaire included questions from four screening tools: the Basic Nordic Sleep Questionnaire, the Brief Infant Sleep Questionnaire, the Infant Sleep Questionnaire and the Sleep Disturbance Scale for Children (17–20).

The Sleep Disturbance Scale for Children (18) is a rating scale developed for the evaluation of sleep disorders in children. To assess sleep-disordered breathing, we used questions from the sleep-disordered breathing subscale. On this scale the response alternatives were *always* indicating daily, *often* suggesting three to five times per week, *sometimes* meaning once or twice per week, *occasionally* indicating once or twice per month and *never*.

The infants' birthweight, length and gestational age were collected from the hospital records.

Statistical analysis

Frequency analyses were performed first. The prevalence and persistence of snoring was assessed. We then evaluated how snoring was related to parent-reported infant sleep quality. The comparisons were based on *t*-tests or the chi-square test depending on type of the variable to be analysed. Next, we performed bi-variable analyses between snoring and the potential risk factors using the chi-square test. In these analyses, we combined the frequency of snoring into a dichotomy as follows: the habitual snorers stood for snoring at least three times per week versus infants snoring less than three times per week. Based on the findings of previous studies among infants, the potential risk factors considered were formula feeding, parental snoring and parental smoking. Dummy use was studied because of its similarity to bottle feeding.

Finally, ordinal logistic regression models were constructed in order to study which of the risk factors previously listed were significantly related to snoring at the ages of three and eight months when the infant's age, sex, allergies and number of infections, plus the parents' education and income, were controlled for. We used three ordinal categories with the following cut-off points: snoring never or one or two times per month (n = 1241 at the age of three months and n = 1089 at the age of eight months), snoring one to two times per week (n = 103 at three months and n = 90 at eight months) and habitual snoring indicating snoring three to five times per week or always (n = 44 at three months and n = 37 at eight months).

RESULTS

There were 1388 infants (52.4% boys) in the sample at the age of three months and 1216 infants (52.0% boys) at the age of eight months. The mean gestational age was 40 weeks. A small number of the infants (1.7%) were born prematurely at 33–36 + 6 weeks of gestation. Four of them were habitual snorers.

The parents reported chronic illnesses as follows: one infant with Down syndrome, Turner syndrome and Crouzon syndrome, 10 infants with apnoeas of infancy and three infants with laryngomalacia. Only the infant with Crouzon syndrome and one infant with laryngomalacia were habitual snorers. All the analyses were carried out excluding the infants with illnesses and prematurity, and the results remained virtually the same.

Some 64.6% of the infants were exclusively breastfed during the first three months. Most of the three-month-old infants (70.8%) used a dummy and the majority (74.3%) slept in a supine position. At the age of eight months, 40.1% of the infants were receiving breast milk and no formula milk. The majority of the infants (59.9%) were using a dummy at the age of eight months. Most of the eight-month-old infants slept in a lateral position (52.5%) or supine position (42.7%).

The prevalence of snoring

In total, 10.6% of the families with a 95% confidence interval (95% CI) of 9.0–12.2% reported that their child had snored at least once a week at the age of three months. The corresponding prevalence of weekly snoring at the age of eight months was 10.4% (95% CI: 8.7–12.1%). Some 3.2% (95% CI: 2.3–4.1%) of the infants at three months and 3.0% (95% CI: 2.0–3.0%) at eight months were snoring at least

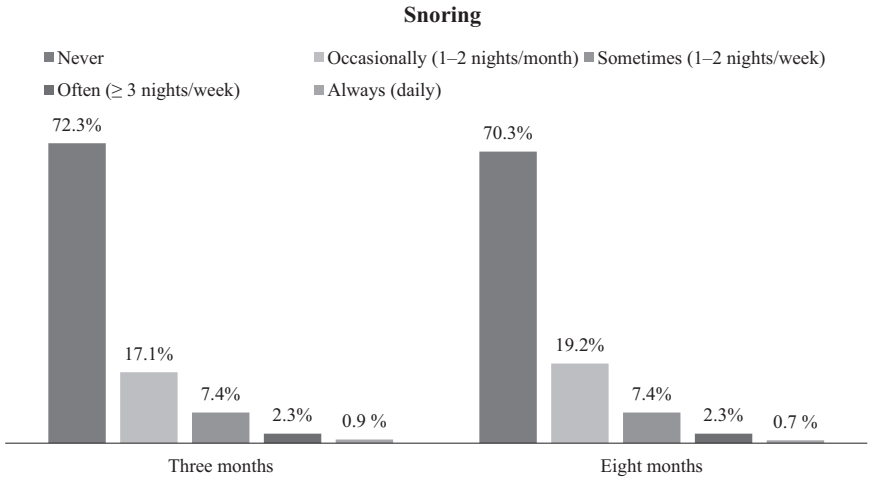

Figure 1 The prevalence (%) of snoring at the age of three and eight months.

three nights per week. The detailed prevalence rates are shown in Figure 1. There were 15 infants (1.1%, 95% CI: 0.6–1.7%) who snored habitually and 53 infants who snored weekly (3.8%, 95% CI: 2.8–4.8%) based on parental reports at both measurement points. There were six habitually snoring infants (0.4%) whose parents only answered the questionnaire at the age of three months.

Factors associated with snoring

The factors associated with habitual snoring in bi-variable models are shown in detail in Tables 1 and 2. The infants who were diagnosed with gastro-oesophageal reflux snored significantly more ($p = 0.017$) than those not suffering from reflux at the age of three months. At the age of three months, the infants who were exclusively breastfed snored significantly less than the infants who were receiving formula milk ($p = 0.024$). Birth characteristics, allergies, colic, the number of respiratory infections and dummy use did not associate with habitual snoring during infancy.

Infants who snored habitually at the age of three months had fathers with a significantly higher body mass index (BMI) (26.3 versus 27.7 kg/m^2, $p = 0.014$) and a lower frequency of higher education ($p = 0.031$). Infants whose mother snored habitually had a greater risk of snoring at the age of eight months ($p = 0.033$). The infants of habitually snoring fathers had a greater risk of snoring as well at both the age of three months ($p = 0.003$) and at eight months ($p = 0.039$). The infants of smoking mothers had a greater risk of snoring both at the age of three months ($p = 0.031$) and at the age of eight months ($p = 0.018$) (Table 3).

The sleep of snoring infants

At the age of three months the sleep length of habitually snoring infants was more than one hour shorter than those who snored weekly or less ($p < 0.001$) but this was no longer the case at eight months ($p = 0.057$) (see Fig. 2). The infants' sleep was considered to be restless when there were several arousals and periods of wakefulness at night lasting more than 20 minutes at a time. The sleep of habitually snoring infants was more restless ($p = 0.004$, OR 3.88, 95% CI: 1.70–8.86) at the age of three months. However, at the age of eight months the difference was no longer seen ($p = 0.102$, OR 2.96, 95% CI: 0.86–10.42) (see Fig. 3). In addition, the sleep of habitually snoring infants was more often considered problematic by parents at three months ($p = 0.034$, OR 3.11, 95% CI: 1.18–8.21) and at eight months ($p < 0.001$, OR 4.63, 95% CI: 2.16–9.94; Fig. 4).

There was no difference in the sleeping place between snorers and the infants who did not snore at three months ($p = 0.101$, OR 0.59, 95% CI: 0.29–1.19) nor at eight months ($p = 0.256$, OR 1.39, 95% CI: 0.65–3.01). Some 80% of the infants at the age of three months slept in the same room as their parents and 64% did so at the age of eight months.

The adjusted risk

Ordinal logistic regression analysis was used in calculating ORs adjusted for the infant's sex, age, earlier respiratory infections and the infant's allergies, plus the parents' lower level of education and lower income. We added the potential risk factors listed previously to the model. The adjusted odds ratios (aORs) are shown in Table 4.

When the confounding factors were controlled for in the adjusted models, exclusive formula milk feeding (aOR = 1.48) and dummy use (aOR = 1.56) were significantly associated with snoring at the age of three months. In both age groups, parental snoring (aOR = 1.65 and 2.60) and maternal smoking (aOR: 2.21 and 2.17) add to the risk of snoring. In all models, of the background factors, male sex was significantly associated with snoring (aOR = 1.55–2.20, $p = 0.001$–0.047).

DISCUSSION

The reported prevalence of snoring in our study was 3.2% at the age of three months and 3.0% at the age of eight months,

Table 1 The characteristics of the study population, infant factors†

Study population	Three months: All infants (N = 1388)	Three months: Non-habitual snorers (N = 1344)	Three months: Habitual snorers (N = 44)	p*	Eight months: All infants (N = 1216)	Eight months: Non-habitual snorers (N = 1179)	Eight months: Habitual snorers (N = 37)	p*
Boys N (%)	728 (52.4)	702 (52.2)	26 (59.1)	0.444	632 (52.0)	617 (52.3)	15 (40.5)	0.182[1]
Age, days, Mean ± SD	97 ± 12	97 ± 14	100 ± 12	0.166	247 ± 9	246 ± 8.8	250 ± 14	0.261
Gestational age, weeks, Mean ± SD	40 ± 1.3	40 ± 1.3	40 ± 1.6	0.157	40 ± 1.3	40 ± 1.3	40 ± 1.5	0.827
Birthweight, grams, Mean ± SD	3580 ± 460	3580 ± 460	3570 ± 380	0.850	3580 ± 460	3580 ± 460	3450 ± 400	0.101
Weight, grams Mean ± SD	6320 ± 740	6190 ± 790	6400 ± 760	0.110	8750 ± 1150	8830 ± 1050	8890 ± 1400	0.754
Milk allergy, N (%)	13 (0.9)	11 (0.8)	2 (4.5)	0.061	52 (4.3)	49 (4.2)	3 (8.1)	0.208
Other allergies, N (%)	7 (0.5)	7 (0.5)	0 (0)	1.000	44 (3.6)	41 (3.5)	3 (8.1)	0.146
Gastro-oesophageal reflux, N (%)	**49 (3.5)**	**44 (3.3)**	**5 (11.4)**	**0.017**	52 (4.3)	48 (4.1)	4 (10.8)	0.069
Infantile colic, N (%)	46 (3.3)	45 (3.3)	1 (2.3)	1.000	22 (1.8)	21 (1.8)	1 (2.7)	0.496
One or more respiratory infections, N (%)	310 (22.3)	297 (22.1)	13 (29.5)	0.269	734 (60.4)	708 (60.1)	26 (70.3)	0.236
Dummy use, N (%)	983 (70.8)	948 (70.5)	35 (79.5)	0.239	728 (59.9)	705 (59.8)	23 (62.2)	0.866
Formula milk feeding, N (%)	**491 (35.4)**	**468 (34.8)**	**23 (52.3)**	**0.024**	728 (59.9)	706 (59.9)	22 (59.5)	1.000

*To compare habitually snoring infants to other infants, p-value is based on t-test or chi-square test depending on the variable type.
†Data shown as mean with standard deviation or proportion as appropriate. The statistically significant factors are bolded.

which is lower than reported earlier (2–6). Only 15 infants snored both at the ages of three and eight months when reported by parents. Previous studies concerning infants have reported a 5–14% prevalence of habitual snoring (2–6). In our study, 65% of the three-month-old infants were exclusively breastfed and 22% were fed both breast milk and formula milk. The protective aspect of breastfeeding may partly explain the lower prevalence of habitual snoring. Furthermore, in the present study, the cohort was skewed towards a higher educational background.

Primary snoring is not a benign condition. In previous studies snoring has been associated with neurocognitive disturbances in infants (21,22). Among older children, snoring has also been linked to cardiovascular disorders (23,24) and behavioural disorders (7,25). For these reasons, it is essential to identify the risk factors for snoring. These factors – including formula feeding, dummy use, maternal smoking and parental snoring – were largely the same as those reported in previous studies. In this study, snoring in infants was associated with male gender in ordinal logistic regression models, as has been previously reported (7–9). The explanation for this association is not clear and requires further study.

Consistent with our findings, breastfeeding has previously been shown to be protective against sleep-disordered breathing (4,12–14). Upper airway obstruction during the infant's sleep is mainly caused by decreased upper airway muscle tone, high nasal resistance and a compliant chest wall (1). The oral muscles are exercised in suckling, and breastfeeding has an important influence on the growth of the mandible (26). During breastfeeding, the tongue action shapes the palate by rounding and flattening it. During bottle feeding and dummy use, the tongue cannot reach the palate (27). A short duration of breastfeeding has been associated with malocclusion (28). There is also evidence that myofascial education can be beneficial in the treatment of obstructive sleep apnoea (29).

It seems that there are multifactorial mechanisms behind infant snoring, including several intrinsic components, environmental factors and genetic aspects. In our study, parental snoring was an independent risk factor for infant snoring. The association of a parental history of snoring and sleep-disordered breathing has been reported earlier (9,30). However, the mechanism of this association is unknown. One explanation could be the inheritance of facial anatomy, which has been reported to affect the risk of snoring (1).

Higher paternal BMI was significantly associated with infants' snoring at the age of three months in this study. It is well known that obesity is related to snoring in the adult population. The interconnection with the father's higher BMI may reflect the association of the father's and infant's snoring.

Lower socioeconomic status has been reported as a risk factor for children's snoring (7,10). In our study cohort, the infants of fathers with a higher education snored significantly less at the age of three months but not thereafter. As discussed earlier, the majority of fathers in our cohort were highly educated, which may explain the finding.

Table 2 The characteristics of the study population, familial factors*

	Three months				Eight months			
Study population	All infants (N = 1,388)	Non habitual snorers (N = 1,344)	Habitual snorers (N = 44)	p**	All infants (N = 1,216)	Non habitual snorers (N = 1,179)	Habitual snorers (N = 37)	p**
Maternal BMI, Mean±SD	28.2 ± 4.3	28.2 ± 4.3	29.4 ± 4.4	0.129	28.2 ± 4.3	28.2 ± 4.3	28.1 ± 4.4	0.942
Paternal BMI, Mean±SD	**26.3 ± 3.6**	**26.3 ± 3.5**	**27.7 ± 5.0**	**0.014**	26.3 ± 3.6	26.3 ± 3.5	26.4 ± 3.7	0.834
≥ 3 children in the family, N (%)	174 (12.5)	171 (12.7)	3 (6.8)	0.355	157 (12.9)	155 (13.1)	2 (5.4)	0.293
Firstborn, N (%)	853 (61.5)	509 (37.9)	26 (59.1)	0.755	727 (59.8)	467 (39.6)	22 (59.5)	1.000
Maternal tertiary qualification, N (%)	847 (61.0)	824 (61.3)	23 (52.3)	0.271	796 (65.5)	776 (65.8)	20 (54.1)	0.160
Paternal tertiary qualification, N (%)	**673 (48.5)**	**659 (49.0)**	**14 (31.8)**	**0.031**	640 (52.6)	557 (47.2)	19 (51.4))	0.739
Family monthly income < 2000 euros, N (%)	348 (25.1)	337 (25.1)	11 (25.0)	1.000	324 (26.6)	311 (26.4)	13 (35.1)	0.257
Maternal snoring ≥3 nights/week, N (%)	159 (11.5)	154 (11.5)	5 (11.4)	1.000	**145 (11.9)**	**136 (11.5)**	**9 (24.3)**	**0.033**
Paternal snoring ≥3 nights/week, N (%)	**381 (27.4)**	**360 (26.8)**	**21 (47.7)**	**0.003**	**335 (27.5)**	**319 (27.1)**	**16 (43.2)**	**0.039**
Maternal smoking <6 months ago, N (%)	**57 (4.1)**	**52 (3.9)**	**5 (11.4)**	**0.031**	**52 (4.3)**	**47 (4.0)**	**5 (13.5)**	**0.018**
Paternal smoking <6 months ago, N (%)	431 (31.1)	414 (30.8)	17 (38.6)	0.320	364 (29.9)	349 (29.6)	15 (40.5)	0.200

*Data shown as mean with standard deviation or proportion as appropriate. The statistically significant factors are bolded.
**To compare habitually snoring infants to other infants, p-value is based on t-test or X^2 –test depending on the variable type.

Table 3 The crude associations between risk factors and habitual snoring at three and eight months*

	Three months			Eight months		
	OR	95% CI	p	OR	95% CI	p
Infant factors						
Sex, boy	1.32	0.72–2.43	0.444	0.62	0.32–1.21	0.182
Milk allergy	5.77	1.24–26.85	0.061	2.04	0.60–6.86	0.208
Other allergies	N/A	N/A	1.000	2.45	0.72–8.30	0.146
Gastro-oesophageal reflux	**3.79**	**1.42–10.08**	**0.017**	2.85	0.97–8.36	0.069
Infantile colic	0.67	0.90–4.98	1.000	1.53	0.20–11.70	0.496
One or more respiratory infections	1.48	0.76–2.86	0.269	1.57	0.77–3.21	0.236
Dummy use	1.62	0.77–3.41	0.239	1.08	0.55–2.12	0.866
Formula milk feeding	**2.05**	**1.12–3.74**	**0.024**	0.98	0.50–1.91	1.000
Familial factors						
≥3 children in the family	0.50	0.15–1.64	0.353	0.216	0.09–1.59	0.293
Firstborn	1.11	0.60–2.04	0.755	1.01	0.52–1.98	1.000
Maternal tertiary qualification	0.69	0.38–1.26	0.271	0.61	0.32–1.18	0.160
Paternal tertiary qualification	**0.49**	**0.26–0.92**	**0.031**	0.85	0.44–1.63	0.739
Family monthly income <2000 euros	1.00	0.50–2.0	1.000	1.51	0.76–3.01	0.257
Maternal snoring ≥ nights/week	0.99	0.39–2.55	1.000	**2.47**	**1.14–5.34**	**0.033**
Paternal snoring ≥3 nights/week	**2.50**	**1.37–4.56**	**0.003**	**2.05**	**1.06–3.99**	**0.039**
Maternal smoking <6 months ago	**3.19**	**1.21–8.42**	**0.031**	**3.76**	**1.40–10.09**	**0.018**
Paternal smoking <6 months ago	1.41	0.76–2.62	0.320	1.62	0.83–3.16	0.200

N/A = Not applicable.
*The statistically significant factors are bolded.

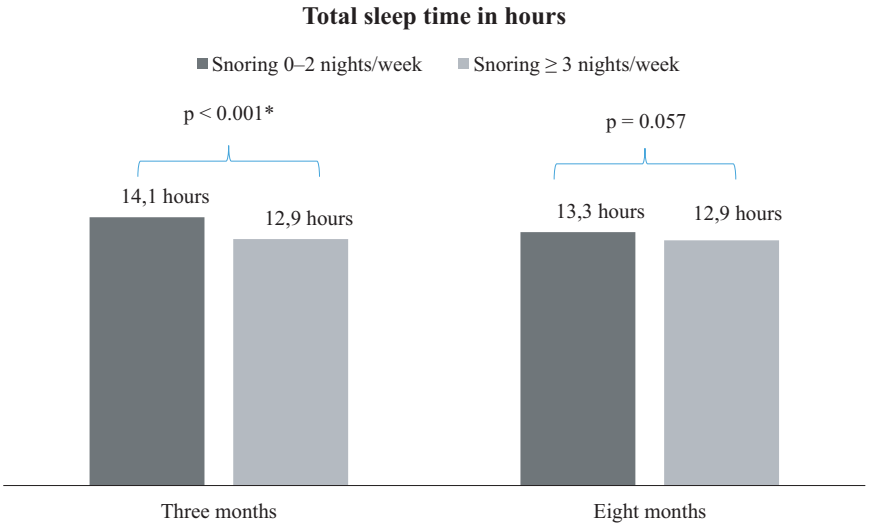

Figure 2 The total sleep time presented (in hours) at the ages of three and eight months among infants who snore two nights per week or less versus habitual snorers.

Maternal smoking increased the risk of snoring at the ages of three and eight months in ordinal logistic regression analysis. This has been shown in previous studies as well (8,10,15). However, paternal smoking had no significant effect on the infant's snoring. The explanation could be the proximity of the mother and infant during the first months of life especially in Finland, where the duration of maternity leave is nine months.

Kuehni et al. (10) found an association between gastro-oesophageal reflux during infancy and snoring among children aged 1–4 years. In our study, the presence of reflux was only significantly associated with snoring at the age of three months.

The parents of snoring infants reported significantly more sleeping problems. The sleep length of habitually snoring infants was shorter and the sleep was more restless, which

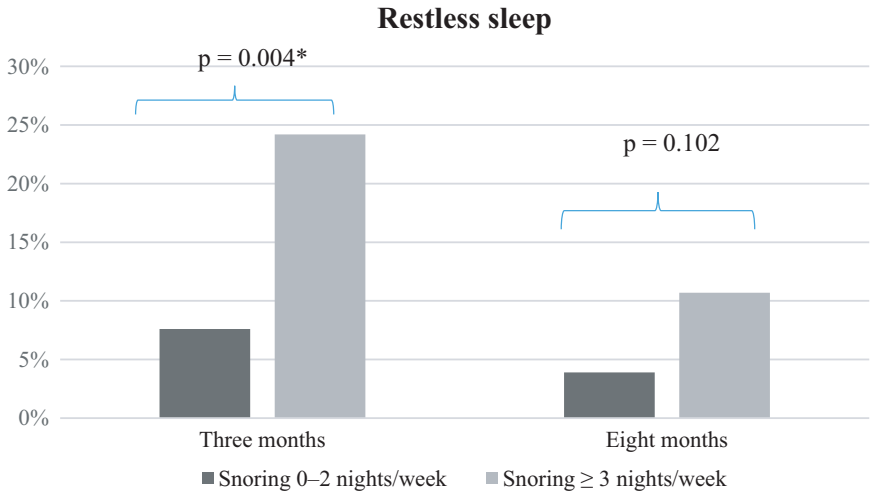

Figure 3 The prevalence of restless sleep (several arousals and periods of wakefulness at night lasting more than 20 minutes at a time) at the ages of three and eight months among infants who snore two nights per week or less versus habitual snorers.

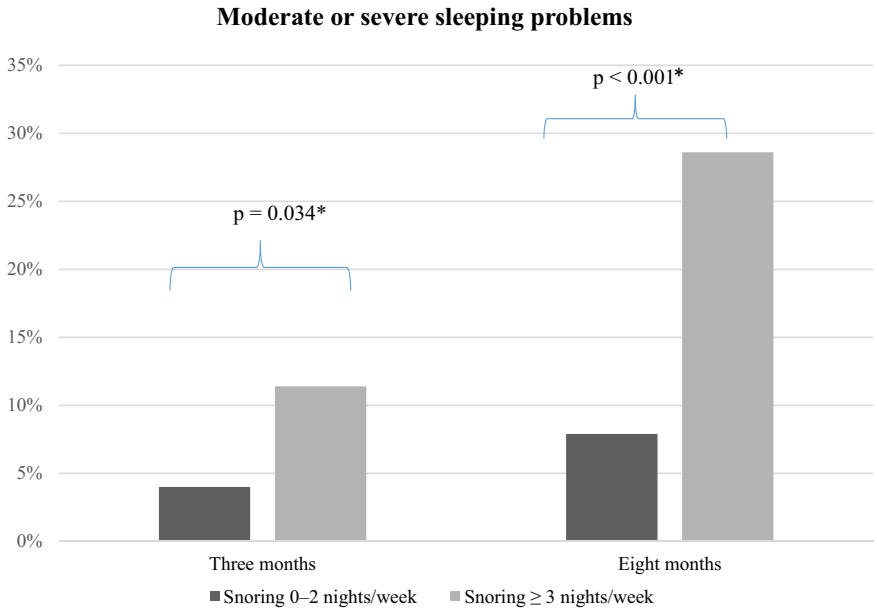

Figure 4 The prevalence of sleeping difficulties at the ages of three and eight months among infants who snore two nights per week or less versus habitual snorers.

can be a sign of the harmfulness of snoring. Even though it is natural for infants to have several arousals from sleep, it is important to note that there might be some non-physiological aspects behind the baby's restless sleep as well. It is important for physicians treating infants and their family to pay attention to parents' reports of infant sleeping problems and to ask specifying questions in order to identify any sign of a snoring disorder. While the treatment of snoring during infancy is remarkably controversial, our results support an active approach and the consideration of the intervention in snoring even in this young population.

Strengths and limitations

This longitudinal study on the prevalence of snoring in infants is based on a large and representative population-based follow-up sample comprising 1388 families. As far as we know, this is the first study to report both maternal and paternal factors associated with infant snoring. In this study, the prevalence of snoring was lower than reported previously, and thus, the number of habitual snorers remained small. In further studies, even larger samples are needed in order to confirm the findings of our study and to study factors that are related to persistent snoring.

Table 4 Ordinal logistic regression models to predict snoring*

	Three months			Eight months		
	aOR	95% CI	p-value	aOR	95% CI	p-value
Formula milk feeding	**1.48**	**1.04–2.10**	**0.028**	0.69	0.45–1.05	0.081
Dummy use	**1.56**	**1.03–2.36**	**0.037**	0.78	0.50–1.24	0.293
Parental snoring	**1.65**	**1.10–2.46**	**0.015**	**2.60**	**1.65–4.10**	**<0.001**
Maternal smoking	**2.21**	**1.04–4.50**	**0.014**	**2.17**	**1.01–4.69**	**0.039**
Paternal smoking	1.10	0.76–1.59	0.628	0.92	0.58–1.47	0.730

aOR = Adjusted odds ratio.

*Data were adjusted for the infant's sex, age, earlier respiratory infections and allergies, as well as the parents' education and income. Three ordinal categories were used with the following cut-off points: never or less-than-weekly snoring, weekly snoring (snoring 1–2 nights per week) and habitual snoring (snoring at least three nights per week). The statistically significant factors are bolded.

The snoring prevalence was based on parental reports of their infant's sleep, and polysomnography was not included in the study protocol. Parental reports of snoring may not always be accurate particularly if the parents are not sleeping in the same room as the infants. In this sample, most of the infants slept in the same room as the parents and there was no difference in the sleeping place between the snorers and non-snorers. Based on this, we assume that parents can assess the prevalence of snoring relatively accurately. Further studies should consider including polysomnography in the study protocol in order to increase the reliability of the findings.

CONCLUSION

Sleep-disordered breathing is a long-lasting condition with a significant influence on the health and well-being of children, so it is essential to identify the children with symptoms of sleep-disordered breathing as early as possible. However, the reported prevalence of snoring in our study is lower than reported earlier. We found that breastfeeding was a protective factor against snoring. This is valuable information to highlight when motivating mothers to breastfeed.

Several of the risk factors reported both in this study and previously – including formula feeding, dummy use and maternal smoking – can be modified. For this reason it is important to already identify these risk factors during infancy in order to diminish the risk of snoring. Paediatricians should also remember to consider snoring when evaluating a child's restless sleep. Furthermore, longitudinal studies are needed in order to clarify the factors behind snoring in infants and the health consequences in later life.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to disclose.

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References

1. Arens R, Marcus CL. Pathophysiology of upper airway obstruction: a developmental perspective. *Sleep* 2004; 27: 997–1019.
2. Montgomery-Downs HE, Gozal D. Sleep habits and risk factors for sleep-disordered breathing in infants and young toddlers in Louisville, Kentucky. *Sleep Med* 2006; 7: 211–9.
3. Kelmanson IA. Snoring, noisy breathing in sleep and daytime behaviour in 2-4-month-old infants. *Eur J Pediatr* 2000; 159: 734–9.
4. Bonuck KA, Chervin RD, Cole TJ, Emond A, Henderson J, Xu L, et al. Prevalence and persistence of sleep disordered breathing symptoms in young children: a 6-year population-based cohort study. *Sleep* 2011; 34: 875–84.
5. Piteo AM, Lushington K, Roberts RM, van den Heuvel CJ, Nettelbeck T, Kohler MJ, et al. Prevalence of snoring and associated factors in infancy. *Sleep Med* 2011; 12: 787–92.
6. Gislason T, Benediktsdottir B. Snoring, apneic episodes, and nocturnal hypoxemia among children 6 months to 6 years old. An epidemiologic study of lower limit of prevalence. *Chest* 1995; 107: 963–6.
7. Gill AI, Schaughency E, Galland BC. Prevalence and factors associated with snoring in 3-year olds: early links with behavioral adjustment. *Sleep Med* 2012; 13: 1191–7.
8. Mitchell EA, Thompson JM. Snoring in the first year of life. *Acta Paediatr* 2003; 92: 425–9.
9. Kaditis AG, Finder J, Alexopoulos EI, Starantzis K, Tanou K, Gampeta S, et al. Sleep-disordered breathing in 3,680 Greek children. *Pediatr Pulmonol* 2004; 37: 499–509.
10. Kuehni CE, Strippoli MP, Chauliac ES, Silverman M. Snoring in preschool children: prevalence, severity and risk factors. *Eur Respir J* 2008; 31: 326–33.
11. Jara SM, Benke JR, Lin SY, Ishman SL. The association between secondhand smoke and sleep-disordered breathing in children: a systematic review. *Laryngoscope* 2015; 125: 241–7.
12. Galbally M, Lewis AJ, McEgan K, Scalzo K, Islam FA. Breastfeeding and infant sleep patterns: an Australian population study. *J Paediatr Child Health* 2013; 49: E147–52.

13. Brew BK, Marks GB, Almqvist C, Cistulli PA, Webb K, Marshall NS. Breastfeeding and snoring: a birth cohort study. *PLoS One* 2014; 9: e84956.
14. Montgomery-Downs HE, Crabtree VM, Sans Capdevila O, Gozal D. Infant-feeding methods and childhood sleep-disordered breathing. *Pediatrics* 2007; 120: 1030–5.
15. Paavonen EJ, Strang-Karlsson S, Raikkonen K, Heinonen K, Pesonen AK, Hovi P, et al. Very low birth weight increases risk for sleep-disordered breathing in young adulthood: the Helsinki Study of Very Low Birth Weight Adults. *Pediatrics* 2007; 120: 778–84.
16. Paavonen EJ, Saarenpaa-Heikkila O, Polkki P, Kylliainen A, Porkka-Heiskanen T, Paunio T. Maternal and paternal sleep during pregnancy in the Child-sleep birth cohort. *Sleep Med* 2017; 29: 47–56.
17. Sadeh A. A brief screening questionnaire for infant sleep problems: validation and findings for an Internet sample. *Pediatrics* 2004; 113: e570–7.
18. Bruni O, Ottaviano S, Guidetti V, Romoli M, Innocenzi M, Cortesi F, et al. The Sleep Disturbance Scale for Children (SDSC). Construction and validation of an instrument to evaluate sleep disturbances in childhood and adolescence. *J Sleep Res* 1996; 5: 251–61.
19. Partinen M, Gislason T. Basic Nordic Sleep Questionnaire (BNSQ): a quantitated measure of subjective sleep complaints. *J Sleep Res* 1995; 4: 150–5.
20. Morrell JMB. The infant sleep questionnaire: a new tool to assess infant sleep problems for clinical and research purposes. *Child Psychol Psychiatry Rev* 1999; 4: 20–6.
21. Piteo AM, Kennedy JD, Roberts RM, Martin AJ, Nettelbeck T, Kohler MJ, et al. Snoring and cognitive development in infancy. *Sleep Med* 2011; 12: 981–7.
22. Montgomery-Downs HE, Gozal D. Snore-associated sleep fragmentation in infancy: mental development effects and contribution of secondhand cigarette smoke exposure. *Pediatrics* 2006; 117: e496–502.
23. Li AM, Au CT, Ho C, Fok TF, Wing YK. Blood pressure is elevated in children with primary snoring. *J Pediatr* 2009; 155: e1.
24. Vlahandonis A, Yiallourou SR, Sands SA, Nixon GM, Davey MJ, Walter LM, et al. Long-term changes in blood pressure control in elementary school-aged children with sleep-disordered breathing. *Sleep Med* 2014; 15: 83–90.
25. Biggs SN, Vlahandonis A, Anderson V, Bourke R, Nixon GM, Davey MJ, et al. Long-term changes in neurocognition and behavior following treatment of sleep disordered breathing in school-aged children. *Sleep* 2014; 37: 77–84.
26. Westover KM, DiLoreto MK, Shearer TR. The relationship of breastfeeding to oral development and dental concerns. *ASDC J Dent Child* 1989; 56: 140–3.
27. Palmer B. Snoring and sleep apnoea: how it can be prevented in childhood. *Breastfeed Rev* 2006; 14: 11–4.
28. Karjalainen S, Ronning O, Lapinleimu H, Simell O. Association between early weaning, non-nutritive sucking habits and occlusal anomalies in 3-year-old Finnish children. *Int J Paediatr Dent* 1999; 9: 169–73.
29. Villa MP, Brasili L, Ferretti A, Vitelli O, Rabasco J, Mazzotta AR, et al. Oropharyngeal exercises to reduce symptoms of OSA after AT. *Sleep Breath* 2015; 19: 281–9.
30. O'Brien LM, Holbrook CR, Mervis CB, Klaus CJ, Bruner JL, Raffield TJ, et al. Sleep and neurobehavioral characteristics of 5- to 7-year-old children with parentally reported symptoms of attention-deficit/hyperactivity disorder. *Pediatrics* 2003; 111: 554–63.

